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Albert M. Day, Director

Special Scientific Report No. 58

A REPORT ON THE APPEARANCE OF THE FUNGUS *ICHTHYOSPORIDIUM HOFERI* IN THE HERRING OF THE NORTHWESTERN ATLANTIC

by

Leslie W. Scattergood

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Leslie W. Scattergood, Aquatic Biologist
Branch of Fishery Biology

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INTRODUCTION

During the past year, the United States Fish and Wildlife Service, in cooperation with the Maine Sardine Packers Association and the Maine Department of Sea and Shore Fisheries, has been carrying on an investigation of the occurrence of a fungus in the herring. When this fungus is particularly abundant in the flesh of the herring, small pus sacs or open lesions appear on the surface of the fish. These occasional severe external manifestations of fungus attacks have drawn the attention of the United States Pure Food and Drug Administration. The presence of the fungus has been labeled as a filthy substance by that agency, which has considered fungus-infected fish as unsuitable for interstate shipment. Condemna-

tion of these fish is based on aesthetic reasons, for it is known that the fungus is not harmful to humans. The decisions of the Food and Drug Administration are wholly the concern of that agency, the Maine State Division of Inspection and the herring industry. We have been primarily interested in the occurrence of the disease in the fish.

The fungus attacking the herring is identical or similar to Ichthyosporidium hoferi. This organism has been found in a number of fresh-water and marine fishes. In Europe, it is known to occur in flounders, mackerel, haddock and several species of trout. To our knowledge, it has not been reported from any European members of the herring family. In the northwestern Atlantic, it has been found in the winter flounder, herring and alewife. Further investigation might reveal that other species also harbor this organism. However, the herring is probably the chief host for the disease and the other fish may become infected by consuming a fungus- contaminated herring. Fish (1934) was able to infect flounders by feeding them such diseased herring. Considering the great quantities of herring eaten by other species, such as dogfish, silver hake, pollack, codfish and mackerel, it is surprising that the fungus is not more widespread. Fish, in his report on the 1931 herring season, stated that the reason for the apparent immunity of other species of fish was obscure. As we believed that infection in fish other than herring was incidental, no attempt was made to investigate the occurrence of the fungus in those fish which prey on the herring.

Fortunately, there is considerable information concerning the fungus and its effect on the herring. The identity of the fungus was established by Ellis (1930a,b), who found the organisms common in the winter flounder of New Brunswick, Canada. As a result of the later investigations of Fish (1934) and Daniel (1933a,b) in 1931 and Forster in 1939 and 1940, we know the general nature of the fungus and how it affects the fish. Each of these three men has either published his findings or has otherwise presented them to the sardine industry. Some of the individuals concerned with the herring fishery are familiar with these investigations; however, there are many who are either unaware of the studies of these three scientists or have forgotten their observations. If possible, their reports should be studied by all those interested in the Maine herring. The accounts may be somewhat technical to persons other than pathologists; therefore, they have been summarized briefly in more easily understood language as follows:

Observations on the alewife and flounder show that the infection is localized in the internal organs. In the herring, the infection is general, so that both internal and external indications of the attack can often be seen. The musculature of the body, as well as

the heart, liver, spleen, kidneys, intestinal tract and brain, may contain the fungus. In the internal organs, the fungi characteristically appear as small tough white nodules. In extreme cases, the heart may be enlarged several times by the formation of these nodules. The herring may be infected internally with fungi and show no external symptoms. Also, there may be small nodules imbedded in the musculature under the skin and their presence is then difficult to detect without removing the skin. The nodules or cysts are a result of the fish's reaction to the infection, for the herring forms connective tissue around the fungi to try to keep them from spreading to other parts of the body. The connective tissue does not always prove sufficient to contain the organisms and the fungi may break out of the nodule and begin spreading to other parts of the fish. Often the attacks of the fungi cause pus sacs which are visible under the skin, or the outer layer of the skin may be broken and a pepper spot or lesion formed. A fish with pus sacs, pepper spots or lesions can be easily recognized as infected.

Spores, or resting stages of the fungus, leave the fish from the ruptured pus sacs and the open lesions of the herring. A plausible explanation of the means by which the fungus from one herring is transmitted to the other is that these fish may pick up the spores while feeding. The herring often strains its food through its gill rakers and the spores could be ingested in that manner. Or the spores could be consumed by the smaller animals upon which the herring feed and thus gain entry to the herring's body. In Great Britain, Jepps (1937) has found a fungus which may be Ichthyosporidium in Calanus finmarchicus, one of the common copepods or "red feed" upon which the herring often feed. Sproston (1944) states that the fungus is, however, very rare in copepods. As far as we can determine, little work has been carried out on the parasites of the marine copepods of New England of the maritime provinces of Canada. Calanus finmarchicus is, according to Bigelow (1926), the most important member of the plankton, or drifting microscopic life, of the Gulf of Maine. This "red feed" or some other small marine form which might eat the fungus spores and then be eaten by the herring may be the means by which the fungus is dispersed among the fish. To determine the role which copepods or similar organisms may play in the dissemination of the fungus will be a distinct problem in itself.

One noticeable feature of the infection is that some herring at least seem to be able to tolerate severe attacks of the organism. Fish with extensive areas of open sores and pus sacs can be found swimming about in apparently normal fashion within a school. Whether or not infected fish can recover from the disease has not been demonstrated. Experiments to determine this have not been successful

because the herring, whether infected or not, soon died under the artificial conditions in aquaria or live cars.

From what few experiments have been conducted in holding herring, it appears that the growth and enlargement of the infected areas is slow. Artificial cultures of the fungi also show that growth is slow.

After the studies of the herring fungus were terminated, none of the three investigators was able to present any definite conclusions concerning the reason for the occurrence of the increased fungus incidence in some years or the possibility of predicting future outbreaks. With the available information, it was impossible to present more than the basic facts relating to parts of the life history of the fungus and the pathological symptoms it produced in the fish. Scientific predictions can be made only when the most important of the influencing factors are known and evaluated.

The possibility of the cyclic appearance of high rates of infections was mentioned by Fish. His report stated that the fungus was common in 1929 and reached epidemic proportions in 1930 and 1931. Cox (1916) had described an epidemic in the Gulf of St. Lawrence in 1916 and mentioned that the fishermen of that region saw a similar epidemic among herring in 1898. Thus 18 years elapsed between the first two outbreaks on the north shore of New Brunswick, 14 or 15 years elapsed between 1916 and 1930 - 1931 and the heavy infection of 1946 - 1947 occurred 16 or 17 years later. But, as far as we can determine from inquiries and our examinations of fish from that region, there has been no infection in the fish from the Gulf of St. Lawrence for a number of years. Furthermore, one cannot be absolutely positive that the epidemic Cox observed was truly caused by the same organism, although it seems highly probable that Ichthyosporidium was responsible for the outbreak. Because of these two facts, it seems logical to eliminate the Gulf of St. Lawrence herring from consideration in the determination of a cycle. We are left with 1930 - 1931 and 1946 - 1947. These two periods are hardly enough to establish a cycle.

The above is not meant to represent a criticism of the concept of a cyclic appearance, but instead to point out that a cycle of infection has not yet been clearly demonstrated. Nevertheless, there is always the possibility that once the idea of a cycle is implanted in the minds of those concerned with this industry, there will be a tendency for increased alertness when the suspected cyclic period approaches. This may result in closer examinations of the fish and, consequently, the incidence figures obtained with this more exacting scrutiny will be higher than those subjected to a less careful and

perhaps more normal observation. It seems, however, to be unanimously agreed among those who are interested in the condition of the herring that the years 1930 - 1931 and 1946 - 1947 represented high points in the incidence of infection.

INITIATION OF PRESENT RESEARCH

For several years prior to 1947, the Maine sardine industry had been concerned over the apparently increasing incidence of the fungus in the herring. When frequent seizures of canned sardines packed from fish caught in February and March 1947 were made by the Food and Drug Administration and the supplies of fish then available to the fishermen seemed to be heavily infected, the Maine Sardine Packers Association requested the Fish and Wildlife Service to investigate the occurrence of the fungus in the herring. The Association agreed to make available a sum of money to carry on this work and to provide the investigators with fishing boats when requested. At a meeting of the members of the Association and of the Fish and Wildlife Service in April 1947, the need for the following investigations was stated:

1. The development of a practical, accurate and rapid method by which a layman can identify a fish afflicted with the condition known as "pepper spot".

2. The development of a practical, rapid and economical method of sorting out affected fish in the canning plants.

3. The development of a sampling technique to insure that any lot of canned fish will meet the requirements of any governmental inspection agency.

4. The continuous charting of the geographic incidence of the infection.

5. A statistical analysis of the course of the epidemic.

6. An estimation of the effect of the epidemic on the abundance of the sardine population.

7. A survey of the literature of the diseases of marine commercial fishes.

It was further agreed that the Fish and Wildlife Service would direct the investigations and detail at least two scientists of its staff, and such other personnel as might be available when needed, to the study. This the Service has done throughout the investigation. Service biologists John C. Pearson, Louis D. Stringer and John R. Webster were detailed to this study for varying lengths of time in 1947 and the author was engaged in the investigation up to July 1948.

During the period April - June 1947, it was not necessary to use the $2,000 offered to the Service by the Association. The Service was able to finance the investigation during that period, with the exception of the boat operation costs. Transportation to New Brunswick fishing localities was effected on several occasions in boats supplied by the Holmes Packing Co. of Eastport, the Machiasport Canning Co. of Eastport, and the R. J. Peacock Canning Co. of Lubec.

Preliminary results of the investigations made during the spring of 1947 were presented to the Association in June 1947 and a contract to continue the study during the fiscal year 1948 was signed by the Association, the Maine Department of Sea and Shore Fisheries, and the Fish and Wildlife Service. The Association agreed to provide the sum of $6,000 for the investigation, of which $4,500 was to be deposited in the Treasury of the United States and be made available to the Fish and Wildlife Service for expenses incurred in the study. The remaining $1,500 was to be used to pay the salary and half of the expenses of a biologist who was to work under the supervision of the Service. The Maine Department of Sea and Shore Fisheries was to pay half of the expenses of this biologist, who was to collaborate with the Service. Douglass C. Pennoyer was the biologist selected for this position. Salaries of the Service scientists were to be paid from Service funds. A second contract to cover the fiscal year 1949 has been signed by the three agencies concerned and the study is continuing under the same arrangements.

SORTING INFECTED FISH

The problem of devising a system by which infected herring could be quickly and efficiently sorted out prior to canning was of immediate importance to the industry. Unless the percentage of infected fish could be greatly reduced, there was a strong possibility that the resultant canned product would not be allowed to enter interstate trade by the Food and Drug Administration. The solution of this problem engaged the interest of the Association; the Maine Department of Agriculture, Division of Inspection; the U. S. Department of Agriculture, Production and Marketing Administration; the National Canners Association; and the Fish and Wildlife Service.

One of the obvious ways of culling out defective herring is to have personnel examine the fish and discard all those which show signs of the fungus. Endless-type belts to carry single layers of fish in front of a line of women were designed by some of the canners, but experimental use of these belts during the February - March 1947 season did not indicate then that they would be satisfactory. The

women hired to inspect the fish could not seem to reject enough infected fish to bring the percentage of infection down to a safe level.

William S. Hamm, a technologist with the Fish and Wildlife Service's Division of Commercial Fisheries, spent considerable time trying to find some method other than visual inspection to eliminate the defective fish. He found that there did not appear to be any possibility of segregating the infected and non-infected herring by any differences in their specific gravities. It was hoped that such differences might exist and thus a very simple way of sorting the fish could be carried on in the brine tanks at the canneries. Neither was it possible to distinguish more easily the defective fish with artificial lights of various wave lengths.

On June 16, 1947, several of the agencies interested in this problem designed an experiment to determine whether or not it was both possible and practicable to cull out fungus-infected fish by the use of a sorting belt. It was also intended to discover at what points in the processing operations the culling could be most efficiently conducted. A full report of the methods and findings of this experiment was made available to the industry by the National Canners Association. Several conclusions were reached. First, the culling of raw fish, either before or after brining, could be done satisfactorily when the incidence of infection was 15 to 20 percent. Whether or not it was possible to cull lots over 20 percent was not known, as none of the three lots of fish used in the experiment exceeded that figure. Second, sorting after steaming or drying was not economical, for non-infected fish might develop spots or breaks in the skin and thus be discarded by the packers. Third, the use of a microscope was the only positive means to confirm final judgment of the canned fish.

On June 23, shortly after the successful demonstration of the sorting belt technique, the sardine industry resumed operations. Members of the National Canners Association visited almost all the canneries to assist in the development of proper culling procedures. They were aided by inspectors of the Maine Division of Inspection, which department has, as one of its obligations, the responsibility for the inspection of the canned sardines. Factory personnel were trained to detect and discard infected fish and the canners were advised as to the proper method of culling, according to the physical lay-out of the factory. In some sardine plants, it was possible to sort at the flaker or on the flakes and the use of a belt was not necessary. General instructions to the canners concerning the culling techniques were issued in the National Canners Association Bulletin of July 7, 1947.

The culling procedure was carried on throughout the entire season to the evident satisfaction of the state inspectors and the Food and Drug Administration. When a lot of fish containing less than five percent infected individuals was received at a cannery, it was not necessary to delegate personnel to culling, for the packers were then depended upon to reject the defective fish.

A final inspection of the packed sardines before they had been oiled and sealed was instituted to provide a means of checking on the quality of the final product. Another innovation was also made. Each lot of herring entering the factory was assigned a code number and this number was also given to the canned sardines resulting from that lot. Thus, failure of a particular lot of sardines to pass the inspection of the Maine Division of Inspection or the Food and Drug Administration would not mean that the whole day's pack or a whole carload would have to be rejected, but perhaps only that particular lot.

SURVEY OF THE LITERATURE

When instituting a research program, scientific investigators must undertake, as one of their immediate objectives, the compilation and collation of published articles referring to their specific problems. In this particular study, previous work had already been conducted and a review of the literature pertaining to the fungus infection of herring had been published. Daniel (1933a,b) and Fish (1934) had searched through scientific journals for articles referring to the Ichthyosporidium organism and had summarized, in their own reports, the literature concerning this fungus. As far as we can determine, no further reports on Ichthyosporidium hoferi in herring have been made following that of Forster, who, after research on the fungus infection of herring, had presented his findings to the Maine Department of Sea and Shore Fisheries and the Maine Sardine Packers Association, the agencies which employed him to perform an investigation in 1939 and 1940. For a complete list of references to the occurrence of the fungus in marine commercial fish, we recommend the reading of a recent article by Sproston (1944).

Along the lines of our present investigation, little work had been done. While there is considerable information pertinent to the various diseases and ailments of fish and of the ways in which the various harmful organisms affect the fish, there is little known as to how or why epidemics occur. We might add that this lack of complete knowledge concerning epidemics is not confined to fish diseases, but also applies to many of the human illnesses upon the study of which the civilized peoples of the world have spent untold sums. A study of various texts on epidemiology has demonstrated to us, however,

that certain theories have been set forth to explain the sudden outbreaks of disease.

In general, those who study epidemics believe that there are two important and interdependent factors which govern the occurrence of the sudden and widespread attacks of disease which characterize an epidemic. One of the factors is the resistance of the host to a particular disease. Such resistance may depend upon the general health of the host. If a population is in poor condition, due to improper diet or unfavorable environmental conditions, such as extreme cold or heat, then it may be more susceptible to a disease. Also, once the disease has been contracted, a member of such a population may become a great deal more ill than if he were in good physical condition. Another form of resistance may occur after a disease, when the host sometimes develops substances in his body to protect him, for varying periods of time, against future severe attacks of the particular malady.

A second factor which may cause epidemics is the development of new strains of disease organisms. Bacteria and fungi, like all living matter, are in a constant state of change. Each individual organism is a little different from any other individual organism, no matter how closely related. Occasionally, an individual may vary considerably in some respect from his predecessors. The newly acquired difference may, if the organism is a disease producer, increase greatly the virulence of the individual. This individual may reproduce and its offspring carry on the increased virulence. The resistances of the hosts may no longer be sufficient to overcome the effects of the organisms and an epidemic may result. These theories and how they relate to the herring will be discussed later in this report.

INVESTIGATION OBJECTIVES

As a result of former investigations, the effect of the fungus on the herring had been quite well demonstrated. Further work on the pathology of the infection did not seem to be warranted until other lines of work were pursued. It was decided, when the plans for this study were drawn up, that the efforts would be directed towards an analysis of the incidence of the infection, from geographical and temporal standpoints.

It was important to know whether any geographical differences in infection rates existed, for it was conceivable that the fungus might be concentrated in certain local stocks of fish, which would serve as a focal point for the spreading of the infection to other regions. Heavy fishing of the badly infected stocks might then reduce the possibility of more extensive dissemination of the fungus.

It was a general practice for fishermen to catch and then release schools of highly infected herring after their condition was determined, for there was no ready market for sizeable quantities of such fish. Likewise, it seemed important to study the changes in the infection from week to week, month to month, season to season and year to year, for the industry was vitally interested in the possibility of being able to predict the future incidences of the infection on both a short-time and a long-time basis.

An interesting theory pertaining to the reason for outbreaks of the infection among herring has been mentioned previously on a number of occasions. This theory concerns the possible relation between the size of a population and the occurrence of epidemics. It has been generally recognized that, among certain wildlife populations such as the jack rabbit of the western plains of the United States, disease epidemics usually occur when the animals are most abundant. Just why this should happen is not known. One explanation is that the increased population results in an increased competition for food with a consequent reduction in the available food supply, and, because of the resultant malnutrition, a general lowering of body resistance to the disease. Also, with an increased population, it is easier for the disease to be transmitted from one host to the other. After reducing the number of animals to a low level, the incidence of the disease also descends markedly. The rabbit population then begins to increase and, after a few years, again reaches its peak at which time the disease strikes once more. Perhaps the fungus infection and the size of the herring populations vary in a similar manner; however, we do not have enough information on the past history of either the disease or the population densities of the herring to do more than merely mention this theory. Many years of close study of the disease and the herring would be necessary to demonstrate whether or not this theory has any validity when applied to fish populations. It is quite obvious that, if the fungus infection becomes widespread when the population of herring is large, then it might conceivably be possible to keep the numbers of herring below the level conducive to epidemic outbreaks.

The establishment of a statistical system designed to obtain information on the relative availability of the herring was necessary before we could possibly furnish any estimate of the effect of the epidemic on the abundance of the sardine population. Unfortunately, the size of the herring catch along the northwestern Atlantic coast does not always indicate the abundance of the fish, for it has been governed almost entirely by economic factors. It would be a difficult task to ascertain the past abundance of the herring. Such a study would involve the gathering and analysis of a great deal of

information now buried in the record books of the canneries and fishermen along the coast. Perhaps such data would supply us with an index of relative abundance, but we cannot be positive of this until the data have been thoroughly examined. In the meantime, we have commenced an adequate collection of statistics which will provide us with current information regarding the daily catches of individual fishermen, by locality and gear. These data will be invaluable in the future.

GEOGRAPHIC DISTRIBUTION OF FUNGUS-INFECTED HERRING

Table 1 shows the percentages of infections as revealed by our examinations of herring samples from New Brunswick, Canada between April 1947 and June 1948. Tables 2, 3 and 4 show the incidences for Eastern Maine, Central Maine and Western Maine, respectively. The area entitled Eastern Maine lies between Calais and Schoodic Point; Central Maine, between Schoodic Point and Marshall Point, Port Clyde; and Western Maine, between Marshall Point and Richmond Island, Cape Elizabeth. Figures 1, 2 and 3 illustrate these regions. These areas seem to represent fairly natural divisions of the coast and were established by us to assist in the examination of the geographic variations in the fungus incidence. Most of the data shown in Tables 1 - 4 have already been presented to members of the sardine industry. On the 1st and 15th of each month between April 1947 and January 1948, we distributed reports on the incidence of the fungus, as determined by our observations. Information on the fish between February and June 1948, however, has not previously been published.

Tables 1 - 4 indicate that the infection was widespread throughout the New Brunswick and Maine fishing areas. In those regions, our sampling failed to reveal any schools of fungus-free herring. In other parts of the Gulf of Maine, the prevalence of this disease was also demonstrated. In three samples from Provincetown, Massachusetts taken during May 1947, 18.7, 20.2, and 22.6 percent of the fish were infected. A May 1947 sample from Digby, Nova Scotia had a 10.0 percent infection, while an August lot from that region had a 6.3 percent rate. Two 1947 samples from St. Mary's Bay, Nova Scotia, had infection rates of 37.3 percent in June and 6.3 percent in August.

In contrast to the wide distribution of the fungus in the Gulf of Maine, herring samples from the Gulf of St. Lawrence, Canada did not show any infection. April and May 1947 lots of "Shediac" 1/ herring contained no infected fish. The inspectors of the Maine Division of Inspection made numerous examinations of "Shediac" fish without finding any infected ones, to our knowledge, in both the 1947 and 1948 seasons. Information received verbally from members of the Fisheries Research Board of Canada indicates that "sick" fish in the Gulf of St. Lawrence were rarely seen in 1947. No small, immature herring were examined from that area, for such fish are seldom taken by the fishermen. Whether or not the small herring of that region are infected is not known. In view of our experience in the Gulf of Maine, it would seem likely that if the large fish were free of the fungus, then the small ones would also be uncontaminated.

It is somewhat difficult to compare the incidence of infection between the four large areas. Before an accurate comparison could be made, it would be necessary to weight each sample by the size of the lot from which the sample was drawn. This can be done only after a considerable amount of clerical work has been performed -- a task which we did not attempt under the circumstances. As can be seen in Table 5, the general trend of the disease was somewhat similar in all areas during 1947. A particularly noticeable difference existed between the infection rates of New Brunswick - Eastern Maine and Central Maine - Western Maine during a six week period, September 10 to October 4. At that time, the canneries in Eastern Maine were supplied with herring having a relatively low fungus incidence and seldom had to use inspection belts, while factories in the other two Maine areas had to continue to use belts on many occasions to cull out the infected herring.

It seems to us quite important that none of Gulf of Maine herring samples was free of infection, regardless of the place and date of capture. It is quite possible that the disease is always present in varying degrees in the herring. Forster, examining herring in 1939 and 1940, had no difficulty in finding diseased specimens and neither did

1/ "Shediac" herring are spawning fish taken primarily by gill nets in the Gulf of St. Lawrence on the north shore of New Brunswick in the spring months. Although these herring are caught over a fairly extensive area, they have been named for one of the small towns in the Northumberland Strait region.

Fish or Daniel in 1931. Fish's opinion that the organism was a normal parasite of the herring appears to be true.

SEASONAL VARIATION IN INCIDENCE

It is quite apparent from Tables 1 - 5 that the incidence of the infection had a marked seasonal variation. The magnitude of the seasonal change such as was experienced in 1947 was obvious to all engaged in the Gulf of Maine herring fishery. In general, herring samples in April and May from all areas showed high incidence rates. The high rate continued in Western Maine during June and part of July, but in the other areas, it decreased rapidly after May.

By the middle of November, the fishery had ended in Central Maine and by the first of December, the Western Maine season was finished. In both these areas there was no marked increase in infection during the fall. Table 5 shows an infection of 11.3 percent for the four week period ending Dec. 13, but this figure is based on only one sample and cannot be given much consideration as an index of the infection over the entire region during that period.

In New Brunswick and Eastern Maine, the rate of infection began to show an increase in November and December. Eastern Maine herring fishing ceased in the middle of December when the Maine sardine canning season officially ended; however, in New Brunswick, fishing continued during January and February at which time purse seines were used to catch the herring. The Maine sardine canning season officially opened in March. During the first three months of 1948, it was possible to obtain a few samples and these did not seem to show any marked increase over the late fall figures. In February and March, inspectors Mansur Grant, George Harris and George Gott of the Maine Division of Inspection preserved herring from New Brunswick for our later examination and, through the cooperation of these men, we were able to record, for this two month period, data which otherwise would not have been obtained.

In 1948, in the Gulf of Maine, there was an extreme scarcity of available herring between the middle of March and the first of June. A few samples obtained in May and June from New Brunswick indicated that the fish then present in the bays had a somewhat higher infection rate than the fish taken during the winter, but still were in better condition than those in 1947 from the same general area. We were unable to secure herring samples from the Maine coast in 1948 until June. When the fishermen did begin to capture sizeable quantities of herring, principally in Western and Central Maine, the infection was so low that, in most cases, it was unnecessary to use the inspection belts.

Table 1. Incidence of *Ichthyosporidium hoferi* in the herring of New Brunswick, Canada.

Locality	Date	Gear	Infected Fish	Fish Examined
			%	No.
Shediac region	4-26-47	Gill Net	0.0	200
Bliss Hbr.	4-29-47	Weir	25.9	293
Back Bay	4-29-47	-do-	26.6	301
-Do-	4-29-47	-do-	24.5	200
Dipper Hbr.	5- 5-47	-do-	40.2	189
Bliss Hbr.	5-14-47	-do-	22.0	291
Back Bay	5-14-47	-do-	23.5	298
Seeley Head	5-16-47	-do-	30.2	301
Deer Id., Bar Id.	5-19-47	-do-	14.5	200
Deer Id., Bean Id.	5-20-47	-do-	18.4	201
Shediac region	5-20-47	Gill Net	0.0	50
Dipper Hbr.	5-28-47	Weir	46.7	300
Bliss Hbr.	5-28-47	-do-	50.5	200
Back Bay	5-28-47	-do-	28.3	300
Deer Id., St. Andrews Bay	5-28-47	-do-	25.5	200
Deer Id., Bar Id.	5-29-47	-do-	26.5	300
-Do-	5-29-47	-do-	19.3	300
Bocabec Bay	6- 5-47	-do-	30.0	300
Deer Id., Bar Id.	6- 5-47	-do-	21.9	301
Bliss Hbr.	6-10-47	-do-	25.0	300
-Do-	6-10-47	-do-	33.0	100
Back Bay	6-10-47	-do-	25.0	300
Campobello Id., Welchpool	6-12-47	-do-	17.4	201
Deer Id., Bean Id.	6-16-47	-do-	21.5	500
Campobello Id., Hbr. de Loutre	6-16-47	-do-	17.0	300
Deer Id., Simpson's Id.	6-22-47	-do-	18.5	200
Deer Id., unspecified	6-22-47	-do-	15.3	300
Grand Manan Id., unspecified	6-23-47	-do-	15.0	100
Deer Id., Barn Id.	6-24-47	-do-	17.0	100
Deer Id., Simpson's Id.	6-24-47	-do-	25.0	100
Deer Id., Lords Cove	6-25-47	-do-	13.0	300
Campobello Id., Mill Cove	6-28-47	-do-	29.3	300
Campobello Id., unspecified	7- 3-47	-do-	19.0	100
Deer Id., unspecified	7- 8-47	-do-	15.3	300
Deer Id., Lambertville	7- 9-47	-do-	18.7	300
Campobello Id., Mill Cove	7- 9-47	-do-	21.7	300
Campobello Id., Hbr. de Loutre	7-10-47	-do-	19.2	273
Grand Manan Id., Seal Cove	7-10-47	-do-	10.5	200
Deer Id., Lambertville	7-11-47	-do-	12.3	300
Grand Manan Id., Seal Cove	7-11-47	-do-	17.0	150
Campobello Id., Raccoon Beach	7-11-47	-do-	9.3	300
Campobello Id., Ragged Cove	7-11-47	-do-	12.3	300
Campobello Id., Mill Cove	7-15-47	-do-	29.0	100
Campobello Id., Meadowbrook	7-15-47	Stop Seine	15.7	300

Table 1 (cont.)

Locality	Date	Gear	Infected Fish %	Fish Examined No.
liss Id.	7-16-47	Weir	13.8	297
ew River	7-17-47	-do-	33.2	600
Do-	7-17-47	-do-	31.5	210
eer Id., Bean Id.	7-17-47	Weir	26.7	299
eer Id., Lords Cove	7-17-47	-do-	19.7	278
ipper Hbr.	7-18-47	-do-	12.0	300
eer Id., Leonardville	7-18-47	-do-	24.7	248
ipper Hbr.	7-23-47	-do-	27.7	300
ampobello Id., Mill Cove	7-23-47	-do-	16.0	200
ampobello Id., Meadowbrook	7-23-47	-do-	15.3	300
ack Bay	7-24-47	-do-	16.0	300
ew River	7-30-47	-do-	17.0	300
ipper Hbr.	7-31-47	-do-	17.0	300
eer Id., unclassified	7-31-47	-do-	8.7	300
rand Manan Id., Seal Cove	7-31-47	-do-	8.5	200
liss Id.	7-31-47	-do-	14.1	304
ampobello Id., Schooner Cove	8- 1-47	-do-	7.0	300
liss Hbr.	8- 6-47	-do-	13.3	300
eer Id., Lambertville	8- 6-47	-do-	13.0	290
ryer's Id.	8- 7-47	-do-	14.0	300
ipper Hbr.	8- 7-47	-do-	22.0	300
ocologan Id.	8- 7-47	-do-	24.3	300
ampobello Id., Mill Cove	8- 8-47	-do-	11.5	200
row Hbr.	8-11-47	Stop Seine	6.7	300
ew River	8-12-47	Weir	11.7	300
eer Id., Lords Cove	8-15-47	-do-	13.3	300
'Etang River	8-20-47	-do-	7.7	300
ack Bay	8-20-47	-do-	9.7	300
liss Hbr.	8-21-47	-do-	10.0	300
ack Bay	8-25-47	-do-	3.7	300
t. Andrews Id.	8-27-47	-do-	8.3	301
ampobello Id., Welchpool	8-27-47	-do-	4.8	84
eer Id., Lambertville	9- 5-47	-do-	8.3	300
ack Bay	9-11-47	-do-	6.7	300
liss Hbr.	9-12-47	-do-	4.0	300
eer Id., St. Andrews Bay	9-23-47	-do-	7.7	300
eer Id., unspecified	9-23-47	-do-	5.7	300
ipper Hbr.	9-26-47	-do-	3.0	300
epreau	9-26-47	-do-	3.3	300
'Etang River	9-26-47	-do-	5.7	300
ocologan	9-28-47	-do-	3.7	300
t. Johns Hbr.	9-29-47	-do-	4.7	300
eer Id., Lambertville	9-29-47	-do-	4.0	300
eer Id., Harwood Id.	9-29-47	-do-	3.0	300
ampobello Id., Head Hbr.	9-29-47	-do-	3.3	300

Table 1 (cont.)

Locality	Date	Gear	Infected Fish %	Fish Examined No.
Grand Manan Id., Ingalls Head	9-29-47	Weir	4.7	300
Grand Manan Id., White Head Id.	9-29-47	-do-	3.0	300
Deer Id., Lords Cove	10- 8-47	-do-	4.0	300
Macmaster Id.	10- 9-47	-do-	9.7	300
Minister Id.	10- 9-47	-do-	14.0	300
Musquash Hbr.	10- 9-47	-do-	9.7	300
Deer Id., Lambertville	10- 9-47	-do-	3.7	300
Deer Id., Leonardville	10- 9-47	-do-	7.0	300
Grand Manan Id., White Head Id.	10- 9-47	-do-	4.2	270
Lepreau	10-13-47	-do-	3.0	300
Big Bay	10-14-47	-do-	21.3	300
Campobello Id., Friar Bay	10-15-47	-do-	8.0	300
St. Johns Hbr.	10-15-47	-do-	3.0	300
Bocabec	10-15-47	-do-	20.0	300
St. Andrews Hbr.	10-17-47	-do-	7.7	300
Bliss Hbr.	10-23-47	-do-	8.0	300
Big Bay	10-23-47	-do-	15.7	300
Deer Id., Lambertville	10-23-47	-do-	9.7	300
Campobello Id., Herring Cove	10-28-47	-do-	6.7	300
Campobello Id., unspecified	10-31-47	-do-	5.7	300
St. Andrews Bay	10-31-47	-do-	13.3	300
Letite	10-31-47	-do-	10.0	300
Grand Manan Id., Grand Hbr.	11- 3-47	-do-	9.0	300
St. Andrews Bay	11- 3-47	-do-	9.0	300
Deer Id., Lambertville	11- 4-47	-do-	9.0	300
Deer Id., Lords Cove	11- 4-47	-do-	11.3	300
Campobello Id., Head Hbr.	11- 4-47	-do-	8.3	300
Bocabec	11- 4-47	-do-	24.7	300
St. Andrews Bay	11- 5-47	-do-	19.7	300
St. Croix R., St. Stephens	11-13-47	Stop Seine	16.3	300
Campobello Id., Meadowbrook	11-14-47	Weir	9.0	300
Grand Manan Id., Grand Hbr.	11-14-47	-do-	6.0	300
Grand Manan Id., Seal Cove	11-17-47	-do-	9.0	300
Grand Manan Id., Castalia	11-17-47	-do-	5.0	300
Deer Id., Lords Cove	11-20-47	-do-	8.7	300
Campobello Id., Hbr. de Loutre	11-20-47	-do-	12.7	300
Oak Bay	11-20-47	-do-	15.7	300
St. Croix R., St. Stephens	11-20-47	Stop Seine	21.7	300
Deer Id., mixed	12- 2-47	Weir	28.0	300
Campobello Id., Welchpool	12- 2-47	-do-	10.3	300
Deer Id., Lambertville	12- 3-47	-do-	18.7	300
Grand Manan Id., White Head Id.	12- 5-47	-do-	9.1	264
Grand Manan Id., North Head	12- 5-47	-do-	7.7	300
Deer Id., Lords Cove	12-11-47	-do-	24.0	300
Grand Manan Id., Grand Hbr.	12-12-47	Stop Seine	13.3	300

Table 1 (cont.)

Locality	Date	Gear	Infected Fish %	Fish Examined No.
Beaver Hbr.	1-14-48	Purse Seine	15.3	300
Dark Hbr.	1-19-48	-do-	17.0	300
Pocologan	1-22-48	-do-	11.3	300
-Do-	1-23-48	-do-	6.0	300
Beaver Hbr.	1-28-48	-do-	16.7	300
-Do-	1-28-48	-do-	10.0	300
-Do-	1-29-48	-do-	14.0	250
Deadmans Hbr.	1-30-48	-do-	14.0	300
Pocologan	2- 2-48	-do-	8.0	50
Deadmans Hbr.	2- 8-48	-do-	11.0	100
Lepreau	2-10-48	-do-	8.0	100
Beaver Hbr.	2-11-48	-do-	4.0	100
Deadmans Hbr.	2-13-48	-do-	6.0	100
-Do-	2-16-48	-do-	7.0	100
Lepreau	2-17-48	-do-	10.0	100
-Do-	2-23-48	-do-	6.0	100
Deadmans Hbr. and New River	3- 2-48	-do-	8.0	100
Pocologan	3- 4-48	-do-	14.0	50
Lepreau	3- 5-48	-do-	14.0	50
-Do-	3- 7-48	-do-	4.0	100
-Do-	3-12-48	-do-	4.0	50
Beaver Hbr.	3-13-48	-do-	4.0	50
Lepreau	3-18-48	-do-	8.0	100
-Do-	3-19-48	-do-	13.0	100
-Do-	3-22-48	-do-	11.0	100
-Do-	3-24-48	-do-	12.0	100
-Do-	3-26-48	-do-	6.0	100
Deer Id., Richardsonville	5- 7-48	Weir	16.6	300
-Do-	5-11-48	-do-	12.3	300
-Do-	5-20-48	-do-	14.7	300
-Do-	6-10-48	-do-	14.3	300
New River	6-10-48	-do-	8.0	300
St. Andrews	6-18-48	-do-	17.3	300

Table 2. Incidence of Ichthyosporidium hoferi in the herring of Eastern Maine

Locality	Date	Gear	Infected Fish	Fish Examined
			%	No.
Perry	5-5-47	Weir	20.0	95
-Do-	5-12-47	-do-	16.8	107
Dyers Bay	5-13-47	-do-	31.0	100
Perry	5-20-47	-do-	20.7	300
-Do-	5-21-47	-do-	15.3	301
-Do-	5-23-47	-do-	23.0	200
Pigeon Hill Bay	5-28-47	-do-	36.7	300
-Do-	6- 4-47	-do-	25.3	300
Perry	6- 5-47	-do-	29.0	200
-Do-	6- 5-47	-do-	26.0	300
Narraguagus River	6- 6-47	-do-	37.3	300
Perry	6-11-47	-do-	24.5	200
-Do-	6-11-47	-do-	18.0	100
-Do-	6-11-47	-do-	28.0	100
Pigeon Hill Bay	6-13-47	-do-	16.2	296
Narraguagus River	6-14-47	-do-	39.0	300
Perry	6-16-47	-do-	21.0	500
-Do-	6-22-47	-do-	21.0	300
-Do-	6-25-47	-do-	12.9	293
-Do-	6-25-47	-do-	9.0	100
-Do-	7-10-47	-do-	12.0	300
-Do-	7-11-47	-do-	14.3	300
-Do-	7-11-47	-do-	11.0	300
Bois Bubert Id.	7-17-47	-do-	7.0	300
Dyers Bay	7-17-47	-do-	12.0	300
-Do-	7-17-47	-do-	15.0	300
Perry	8- 6-47	-do-	6.3	301
Bucks Hbr., Bar Id.	8- 8-47	-do-	14.9	301
Jonesport, Eastern Bay	8- 8-47	-do-	7.3	300
Perry	8-12-47	-do-	17.9	301
-Do-	8-19-47	-do-	8.0	300
Jonesport, Eastern Bay	8-21-47	-do-	11.5	200
Perry	9- 5-47	-do-	10.0	300
Cape Wash, Holly Cove	9-10-47	Stop Seine	6.0	300
Roque Bluffs	9-10-47	-do-	5.0	300
Jonesport, Eastern Bay	9-10-47	Weir	4.0	300
Bois Bubert Id.	9-10-47	-do-	3.3	300
Jonesport, Eastern Bay	9-22-47	-do-	2.0	300
Perry	9-29-47	-do-	2.7	300
Boot Cove	9-29-47	-do-	1.0	300
Bailey's Mistake	9-30-47	-do-	4.1	266
Little Machias Bay	9-30-47	-do-	2.7	292
-Do-	10- 8-47	-do-	4.0	300
Perry	10-11-47	-do-	5.3	300
Bailey's Mistake	10-13-47	-do-	10.3	300
Sand Cove	10-13-47	Stop Seine	6.3	300

Table 2. (Cont.)

Locality	Date	Gear	Infected Fish %	Fish Examined No.
North Lubec	10-15-47	-do-	3.0	300
Boot Cove	10-15-47	Weir	5.3	300
Little Machias Bay	10-15-47	-do-	4.0	300
Robbinston, Mill Cove	10-22-47	Stop Seine	5.3	300
Sand Cove	10-22-47	Weir	5.0	300
Hamilton Bay	10-22-47	Stop Seine	5.7	300
Perry	10-23-47	Weir	10.3	300
Boot Cove	10-23-47	-do-	3.0	300
Little Machias Bay	10-23-47	-do-	6.0	300
Perry	11- 3-47	-do-	10.7	300
Holly Cove	11- 5-47	Stop Seine	5.3	300
Little Machias Bay	11- 7-47	Weir	5.3	300
Roque Bluffs	11- 7-47	Stop Seine	5.3	300
Carrying Place Cove	11-17-47	-do-	6.0	300
Little Machias Bay	11-18-47	Weir	6.5	200
Bucks Hbr.	11-18-47	-do-	13.0	300
Holly Cove	11-20-47	Stop Seine	9.0	300
Little Machias Bay	11-21-47	Weir	6.0	300
Jonesport, Eastern Bay	12- 4-47	-do-	9.7	300
Little Machias Bay	12- 4-47	-do-	22.3	300
Holly Cove	12- 6-47	Stop Seine	12.3	300
-Do-	12-12-47	-do-	11.7	300
Perry	6-18-48	Weir	6.3	300

Table 3. Incidence of Ichthyosporidium hoferi in the herring of Central Maine

Locality	Date	Gear	Infected Fish %	Fish Examined No.
Mt. Desert Id., Seal Cove	5-29-47	Weir	25.7	300
-Do-	6- 3-47	-do-	35.0	100
-Do-	6- 8-47	-do-	41.3	300
-Do-	6-14-47	-do-	24.2	265
Isle au Haut	6-27-47	-do-	22.4	299
-Do-	6-27-47	-do-	12.1	199
Swan's Island	6-30-47	-do-	15.2	99
Deer Isle, Stonington	6-30-47	-do-	15.7	300
Mt. Desert Id., Seal Cove	7- 1-47	-do-	22.0	100
Lincolnville Beach	7- 3-47	-do-	9.5	200
Cranberry Islands	7- 7-47	Stop Seine	7.3	200
Mt. Desert Id., Seal Cove	7- 7-47	Weir	18.0	200
Deer Isle, Stinson Neck	7- 7-47	-do-	9.0	200
Muscle Ridges, Wheelers Bay	7- 8-47	Stop Seine	16.0	300
Northport	7- 9-47	Weir	11.7	300
North Haven, Hatchet Cove	7-13-47	-do-	6.3	300
Marshall Id.	7-14-47	Stop Seine	10.0	300
Frenchman Bay, Hulls Cove	7-17-47	-do-	15.4	303
Cranberry Islands	7-17-47	-do-	11.9	301
Frenchman Bay, Sorrento	7-21-47	Weir	11.7	300
Frenchman Bay, Salisbury Cove	7-21-47	Stop Seine	14.3	300
Swan's Id.	7-21-47	-do-	35.6	237
-Do-	7-21-47	Weir	22.3	300
Deer Isle, Sunrise	7-21-47	-do-	23.0	300
Islesboro	7-22-47	Weir	10.3	300
Tenants Hbr.	7-22-47	Stop Seine	21.9	301
Wheelers Bay	7-28-47	-do-	11.6	301
Vinalhaven Hbr.	7-21-47	-do-	20.7	286
Deer Isle, Burnt Cove	7-29-47	Weir	19.3	300
Swan's Id.	8- 3-47	-do-	8.7	300
Marshall Id.	8- 4-47	Stop Seine	6.9	301
Deer Isle	8- 4-47	Weir	12.1	277
Wheelers Bay	8- 4-47	Stop Seine	14.9	284
Cranberry Islands	8- 8-47	-do-	9.7	300
North Haven, Whiskey Cove	8- 8-47	-do-	13.0	300
North Haven, unspecified	8- 9-47	-do-	13.7	300
Cranberry Islands	8- 9-47	-do-	8.6	188
Little Cranberry Id., Islesford	8-11-47	Weir	7.0	200
Tenants Hbr.	8-11-47	Stop Seine	12.0	300
Matinicus Id.	8-11-47	-do-	10.0	300
-Do-	8-12-47	-do-	8.0	200
Cranberry Islands	8-16-47	Stop Seine	7.0	171
-Do-	8-18-47	-do-	7.7	300
Swan's Id.	8-19-47	Weir	7.3	300
Marshall Id.	8-19-47	Stop Seine	6.5	275

Table 3 (cont.)

Marshall Id.	8-19-47	Stop Seine	6.5	201
North Haven	8-19-47	-do-	12.7	300
Marshall Id.	8-25-47	-do-	11.9	151
-Do-	8-25-47	-do-	3.0	200
Cranberry Islands	8-25-47	-do-	5.9	271
Long Id. (Frenchboro)	8-29-47	-do-	12.0	300
Lincolnville Beach	9- 3-47	Weir	10.3	300
Marshall Id.	9- 5-47	Stop Seine	5.3	300
Isle on Haut	9- 6-47	Weir	11.0	300
Cranberry Id.	9- 9-47	Stop Seine	4.9	307
Marshall Id.	9- 9-47	-do-	7.7	300
Muscle Ridges, Hewell Id.	9-15-47	Weir	5.3	300
Tenants Hbr., Wildcat	9-15-47	Stop Seine	5.6	303
Long Id., (Frenchboro)	9-17-47	-do-	10.5	200
Vinalhaven Id.	9-17-47	-do-	11.3	300
Cranberry Islands	9-21-47	-do-	4.9	185
Isle au Haut	9-23-47	Weir	14.0	300
-Do-	9/25/47	Stop Seine	12.0	300
Lincolnville Beach	9-29-47	Weir	3.3	300
Marshall Id.	10-2-47	Stop Seine	8.3	300
North Haven	10- 7-47	Weir	7.3	300
Tenants Hbr., Drift-In Cove	10- 9-47	Stop Seine	6.3	300
Marshall Id.	10-14-47	-do-	5.0	300
Swan's Id.	10-14-47	-do-	8.0	300
Cranberry Islands	10-21-47	-do-	7.0	300
Marshall Id.	10-21-47	-do-	10.0	260
Tenants Hbr., Drift-In Cove	10-21-47	-do-	3.7	300
Isle au Haut	6- 7-48	-do-	4.0	277
Tenants Hbr.	6- 8-48	-do-	5.0	300
Vinalhaven	6- 8-48	Weir	6.7	300
Isle au Haut	6-10-48	Stop Seine	6.0	300
Blackwell's Id.	6-10-48	-do-	5.7	300
Rockport Hbr.	6-15-48	-do-	5.3	300
Isle au Haut	6-15-48	-do-	4.7	300
Owls Head	6-15-48	-do-	4.7	300
Lincolnville Beach	6-16-48	Weir	4.1	300
North Haven	6-16-48	Stop Seine	3.0	300
Northport	6-16-48	Weir	9.0	300
Leadbetter Id.	6-16-48	Stop Seine	4.7	300
Camden Hbr.	6-17-48	-do-	7.3	300
Marshall Id.	6-17-48	-do-	5.0	300
Swan's Id.	6-18-48	Weir	4.7	300
Cranberry Islands	6-18-48	Stop Seine	7.7	300
Camden Hbr.	6-21-48	-do-	5.0	300
North Haven	6-21-48	-do-	3.7	300
Deer Isle, Hatchet Cove	6-21-48	-do-	4.0	300
Lincolnville Beach	6-22-48	Weir	4.3	300
Deer Isle, Burnt Cove	6-22-48	-do-	6.0	300
Swan's Id.	6-23-48	-do-	6.0	300
Flye Id.	6-23-48	-do-	7.3	300
Dyers Id.	6-24-48	Stop Seine	2.7	300

Table 4. Incidence of Ichthyosporidium hoferi in the herring of Western Maine

Locality	Date	Gear	Infected Fish %	Fish Examined No.
Sheepscot Bay, Isle of Springs	6-10-47	Stop Seine	32.8	299
Sheepscot Bay, Cozy Harbor	6-11-47	-do-	20.4	299
Small Point Hbr.	6-12-47	-do-	29.7	293
Sheepscot Bay, Sawyer's Id.	6-13-47	-do-	38.3	300
Linekin Bay	6-26-47	-do-	24.0	200
Boothbay Hbr.	6-27-47	-do-	40.8	196
South Bristol	6-30-47	-do-	25.0	100
Sheepscot Bay, Isle of Springs	7- 4-47	-do-	30.3	300
Casco Bay, Ram Id.	7- 6-47	-do-	23.9	280
Casco Bay, Cliff Id.	7- 6-47	-do-	12.7	300
-Do-	7-14-47	-do-	18.6	313
Casco Bay, Bates Id.	7-21-47	-do-	27.4	80
Casco Bay, Cliff Id.	7-21-47	-do-	28.1	195
Southport Id., Christmas Cove	7-25-47	-do-	60.3	300
Casco Bay, Great Diamond Id.	7-25-47	-do-	21.0	300
-Do-	7-28-47	-do-	38.0	300
Casco Bay, Cliff Id.	7-28-47	-do-	10.7	300
Casco Bay, Bates Id.	7-28-47	-do-	17.5	302
Damariscotta R., Back Narrows	7-28-47	-do-	11.8	203
Southport Id.	8-10-47	-do-	14.7	300
Casco Bay, Cliff Id.	8-10-47	-do-	7.0	100
Casco Bay, Haskell Id.	8-10-47	-do-	7.7	300
Casco Bay, Harpswell	8-17-47	-do-	5.5	325
Casco Bay, Haskell Id.	8-18-47	-do-	7.7	300
Casco Bay, Cliff Id.	8-18-47	-do-	5.3	300
Casco Bay, Barnes Id.	8-24-47	-do-	6.0	300
Casco Bay, Cliff Id.	8-25-47	-do-	7.0	300
Casco Bay, Jewell Id.	8-25-47	-do-	4.0	300
Mascongus Bay, Friendship Id.	8-26-47	-do-	11.3	300
Casco Bay, Thrumcap Id.	8-27-47	-do-	5.0	300
Sheepscot Bay, Herman Hbr.	8-29-47	-do-	30.0	300
-Do-	9- 2-47	-do-	37.3	300
Casco Bay, Cliff Id.	9- 8-47	-do-	8.9	301
Casco Bay, Jewell Id.	9- 8-47	-do-	10.7	300
Port Clyde, Allen Id.	9-12-47	-do-	8.0	300
Casco Bay, Cliff Id.	9-13-47	-do-	6.0	300
Casco Bay, Jewell Id.	9-13-47	-do-	4.7	300
Off Monhegan Id.	9-16-47	Purse Seine	3.6	276
Muscongus Bay, Long Cove	9-23-47	Stop Seine	8.1	284
Muscongus Bay, Cranberry Id.	9-24-47	-do-	2.7	300
Casco Bay, Jewell Id.	9-24-47	-do-	4.0	300
Boothbay Hbr., Ocean Point	9-29-47	-do-	20.0	300
Muscongus Bay, Louds Id.	10- 2-47	-do-	7.3	300
Muscongus Bay, Long Cove	10- 2-47	-do-	7.0	300
Muscongus Bay, Louds Id.	10- 5-47	-do-	7.7	300

Table 4 (cont.)

Johns Bay, Thread of Life	10- 6-47	Stop Seine	14.7	300
Casco Bay, Small Point Hbr.	10- 6-47	-do-	12.7	300
Muscongus Bay, Long Cove	10- 8-47	-do-	7.3	300
Muscongus Bay, Cranberry Id.	10- 9-47	-do-	4.3	300
Casco Bay, Baldhead Cove	10-11-47	-do-	3.0	200
Boothbay Hbr., Ocean Point	10-13-47	-do-	14.7	300
-Do-	10-13-47	-do-	7.0	300
Sheepscot Bay,Sawyer's Id.	10-13-47	-do-	19.3	300
-Do-	10-20-47	-do-	14.0	300
Sheepscot Bay, Christmas Cove	10-20-47	-do-	12.0	300
Casco Bay, Jewell Id.	10-20-47	-do-	5.3	300
Muscongus Bay, Louds Id.	10-20-47	-do-	10.0	300
Muscongus Bay, Cranberry Id.	10-21-47	-do-	7.3	300
Off Monhegan Id.	10-26-47	Purse Seine	9.3	300
Casco Bay, Cliff Id.	10-27-47	Stop Seine	7.7	300
Boothbay Hbr., Heron Id.	11- 3-47	Purse Seine	8.2	196
Boothbay Hbr., Negro Id.	11- 3-47	Stop Seine	4.7	300
Muscongus Bay, Long Cove	11-24-47	-do-	11.3	300
Casco Bay, Quohaug Bay	6- 7-48	-do-	4.0	300
Casco Bay, Small Point Hbr.	6- 7-48	-do-	5.7	300
Johns Bay	6- 7-48	-do-	3.7	300
Casco Bay, Pig Id.	6-14-48	-do-	5.7	300
Casco Bay, Cliff Id.	6-14-48	-do-	3.7	300
Casco Bay, Jewell Id.	6-14-48	-do-	3.0	300
Muscongus Bay, Friendship	6-14-48	-do-	6.0	300
Casco Bay, Small Point Hbr.	6-21-48	-do-	4.3	300
Casco Bay, Orrs Id.	6-21-48	-do-	4.7	300
Muscongus Bay, Friendship	6-21-48	-do-	3.7	300
Casco Bay, Bailey Id.	6-21-48	-do-	2.3	300
Casco Bay, Lowell Cove	6-21-48	-do-	2.7	300
Casco Bay, Great Chebeag Id.	6-21-48	-do-	3.3	300
Muscongus Bay, Friendship	6-23-48	-do-	4.7	300

TABLE 5. Incidence of *Ichthyosporidium hoferi* by Four Week Intervals during 1947 - 1948.

Period Ending		NEW BRUNSWICK 1/			EASTERN MAINE			CENTRAL MAINE			WESTERN MAINE		
		Samples	Total Fish	Infected Fish 2/	Samples	Total Fish	Infected Fish 2/	Samples	Total Fish	Infected Fish 2/	Samples	Total Fish	Infected Fish 2/
1947-1948		No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
May	31	12	3,080	28.8	6	1,308	23.9	1	300	25.7	—	———	———
June	28	15	3,702	21.6	13	3,289	23.6	5	1,163	27.0	6	1,587	31.0
July	26	23	6,255	19.0	6	1,800	8.1	22	5,728	15.4	10	2,481	26.6
Aug.	23	18	5,194	12.7	6	1,703	11.0	19	5,097	10.1	10	2,730	12.6
Sept.	20	6	1,585	6.0	5	1,500	5.7	13	3,532	8.1	13	3,877	11.0
Oct.	18	25	7,470	6.0	12	3,558	4.2	9	2,585	7.7	15	4,384	9.3
Nov.	15	17	5,100	11.3	10	3,000	6.2	3	860	6.7	9	2,596	8.7
Dec.	13	16	4,764	13.4	9	2,600	10.7	—	———	———	1	300	11.3
Jan.	10	—	———	———	—	———	———	—	———	———	—	———	———
Feb.	7	9	2,400	12.5	—	———	———	—	———	———	—	———	———
Mar.	6	10	900	8.8	—	———	———	—	———	———	—	———	———
Apr.	3	12	1,000	8.3	—	———	———	—	———	———	—	———	———
May	1	—	———	———	—	———	———	—	———	———	—	———	———
	29	3	900	14.5	—	———	———	—	———	———	—	———	———
June	26	3	900	13.2	—	———	———	24	7,177	5.3	14	3,200	4.1

1/ Not including fish from north shore of New Brunswick and Gulf of Saint Lawrence.

2/ Each sample given equal weight, regardless of number of herring in sample.

The season of 1947 was evidently somewhat similar to that of 1931 about which Fish (1934) stated: "Apparently the high incidence of infection found during the winter and spring of 1931 was the result of samples taken from a more or less static population living in the shallow water, a region where the transmission of the parasite is most favoured. As the inshore fish were joined by the migrating offshore group the general level fell, indicating that this offshore group was less heavily infected, and that the dilution of the infected fish remaining inshore by the migrating offshore group was the primary reason for the decline in the general infection level, and that it was not caused by a seasonal variation of the disease." We have stated that the incidence of the disease in 1947 had an evident seasonal variation. That such a variation is due to the immigration of offshore fish to inshore areas during the summer would explain the seasonal change in the incidence rate.

It has been quite apparent to all those interested in the herring industry that, in general, highly infected fish are those which are caught in small quantities during the winter and spring months. Exceptions are known to exist. The upper part of Sheepscot Bay, for example, was a producer of fish which had a high incidence of infection throughout the season. This area was, however, not a very productive one in terms of bushels of herring caught.

The effect of temperature on the incidence of infection has also been noted by many. The general opinion has been that the fish are most subject to fungus attacks when the water is cold; the animals sluggish, and the food is not readily available. To consider the effects of catch and temperature on the infection rates, data on the 1947 catch in New Brunswick (Table 6) and in Maine (Table 7), on the surface water temperatures at Eastport, Maine in 1947 (Table 8), and the average surface water temperature at Portland, Maine for the period 1922 - 1946 (Table 9) were plotted as shown in Figures 4 - 7. The 1947 surface water temperatures were not available for Portland, Maine, but the average for the period 1922 - 1946 probably is sufficient for our consideration. It is realized, of course, that there may be other places along the coasts of New Brunswick or Eastern Maine which have water temperatures which may approximate the average for those regions closer than does Eastport. There is no way of our ascertaining this, however, for Eastport is the only spot in Eastern Maine where the water temperatures are obtained. A similar situation exists in the case of Portland, which we will consider as typical of Central and Western Maine.

Table 6. Herring and "Sardine" Catch for Charlotte and St. John Counties, N. B. during 1947

Month	Charlotte County	St. John County	Total
	Pounds	Pounds	Pounds
January	2,247,000	1,200	2,248,200
February	2,564,800	1,000	2,565,800
March	5,577,800	12,700	5,590,500
April	3,379,000	209,000	3,588,000
May	3,557,700	169,000	3,726,700
June	4,756,900	23,000	4,779,900
July	12,409,300	231,000	12,640,300
August	17,864,900	1,060,000	18,924,900
September	19,837,700	3,860,000	23,697,700
October	16,429,100	1,934,500	18,363,600
November	11,080,600	191,000	11,271,600
December	2,179,300	842,600	3,021,900
Total	101,884,100	8,535,000	110,419,100

Table 7. Maine Herring Catch, June - December, 1947

Two Weeks Ending	Eastern Maine	Central Maine	Western Maine	Total
	Bushels 1/	Bushels	Bushels	Bushels
June 28	6,094	15,586	28,942	50,622
July 26	57,671	74,670	113,099	245,440
Aug. 23	125,691	176,149	104,574	406,414
Sept.20	140,428	118,525	97,617	356,570
Oct. 18	93,558	62,578	155,778	311,914
Nov. 15	73,974	19,900	88,469	182,343
Dec. 13	42,251	---	21,555	63,806

1/ One bushel weighs 70 pounds.

Table 8. Surface Water Temperatures at Eastport, Maine in 1947 1/

Month	Fahrenheit Degrees
January	38.4
February	36.3
March	36.4
April	38.0
May	41.1
June	45.5
July	49.8
August	53.6
September	54.8
October	53.0
November	49.6
December	2/

1/ From data supplied by U. S. Coast and Geodetic Survey, Washington, D. C.

2/ Not available at time of inquiry.

Table 9. Average Surface Water Temperatures at Portland, Maine for Period 1922-1946. 1/

Month	Fahrenheit Degrees
January	32.9
February	31.8
March	34.4
April	39.9
May	47.6
June	54.7
July	59.4
August	60.3
September	57.9
October	52.0
November	44.8
December	37.0

1/ From information supplied by U. S. Coast and Geodetic Survey, Washington, D. C.

Figures 4 - 6 show that the catch of herring and the temperature of the surface water have the same trend. In general, the catch increased as the water temperature increased, and as the water temperature decreased, the catch also declined. Considering the evident fluctuations in availability of the herring during the season, it is remarkable that the temperature of the water and the catch are so closely correlated as they appear in the figures. It should be remembered that, in small areas, such as some particular bay or inlet, there will not always appear such a definite correlation between temperature and catch, but when the data from a number of small areas are grouped together, then the relationship can be seen. Graham (1936) has remarked on the peculiar fluctuations of the herring fishery within small areas. Huntsman (1933, 1934) has also remarked on the effect of water temperatures on the catch of herring in Passamaquoddy Bay. Figure 7, for Western Maine, does not show the relationship between the two factors quite so well. Such a variance from the other regions is not unexpected, for there are a great many other variable factors which govern the size of the herring catch during the season. A further investigation of the factors influencing the catches of herring seems to be warranted and such will be effected when enough data have been gathered, tabulated and analyzed.

Figures 4 - 7 also indicate in a general way that the incidence of the disease decreased when the temperature and the catch increased and that, in New Brunswick and Eastern Maine, where the fishery continued on a large scale through November and part of December, there was an increase in the percentage of infected fish as the temperature and the catch descended.

Our observations have indicated that the high rates of fungus infection are found during the winter and spring months of the year when the water is cold and the herring available to the fishermen are found largely in the bays and estuaries. With the careful use of inspection belts such fish can probably be handled safely by the canners, but this procedure would not always be feasible financially. If the canners do not wish to handle the highly infected winter and spring fish, then they must await the appearance of the large summer schools. We do not have enough yearly observations to demonstrate the relationship, if any, between the infection rates of the fish available in the winter and spring and those of the summer fish. It may be possible that the degree of disease incidence during the cold season may indicate the condition of the schools appearing during the summer. Such can be determined only after continued observations are conducted. With the small amount of information which we possess concerning the

herring and with our knowledge of the great variability in biological problems, we would hesitate to say that a high disease incidence in winter and spring fish means a greater than usual incidence in the summer and fall fish. It may be that the winter and spring herring present along the coast, living under the possible unfavorable conditions of cold water and diminished seasonal food supplies, have such a decreased physical resistance to the disease that the infection makes severe inroads on the individuals. On the other hand, the fish living in deeper water may find living conditions more suitable there and not be afflicted so severely. Unfortunately, we have no knowledge of the conditions under which the great bodies of herring spend their lives when they are not present near the surface in the coastal regions.

DISCUSSION

There has been no organized investigation to gather information concerning the life history of the herring of New England. Consequently, in any discussion of this fish we are continually confronted with the lack of understanding about the habits of the herring. Such a condition makes even the formation of theories rather difficult. Until a concerted effort on a large scale is made to investigate thoroughly the herring and the herring fishery, there is not a great deal of hope that we will be able to explain in detail the reasons for the appearances of high disease rates or the fluctuations in availability of the herring populations.

A major investigation of the herring of the Gulf of St. Lawrence is now being carried on by the Canadians. Financed by the governments of Canada, the maritime provinces and Newfoundland, a large scale program has been designed to supply the biological data necessary for the best utilization of this resource. The Canadian Atlantic study is also concerned with a study of the seasonal physical and chemical changes in the water masses of their coast, for undoubtedly those factors play important parts in determining the availability and abundance of the herring. Little study is being done on the herring fishery of the Bay of Fundy, so the facts gathered by the Canadian investigators may not be of direct help in understanding the Maine fishery. A similar large scale herring investigation is being conducted on the Pacific Coast by the Canadian government, and the U. S. Government, through the Fish and Wildlife Service, has been carrying on a study of the Alaska herring for about 20 years.

The Gulf of Maine fishery is unique in that the fishery concentrates so heavily on immature herring. In Alaska, British Columbia and the Gulf of St. Lawrence, the great bulk of herring are three years of age and older. In Maine, most of the fish are in their second year when taken. Few are taken in their first year and few after the second. This great dependence on one age group of fish makes a study of this fishery somewhat more difficult than for others and means that a clear understanding of the Maine herring can be obtained only by studying the Maine herring, not by trying to apply the observations of other investigations to this problem.

LITERATURE CITED

Bigelow, Henry B.
1926 Plankton of the offshore waters of the Gulf of Maine. Bull. U. S. Bur. Fish., vol. 40, pt. 2, pp. 1-509, illus.

Cox, Philip
1916 Investigations of a disease of the herring (Clupea harengus) in the Gulf of St. Lawrence. Contributions to Canad. Biol., 1914-1915 (1916), pp. 81-85, illus.

Daniel, George E.
1933a Studies on Ichthyophonus hoferi, a parasitic fungus of the herring, Clupea harengus. I. The parasite as it is found in the herring. Amer. Jour. Hygiene, vol. 17, no. 1, pp. 262-276, illus.

1933b Studies on Ichthyophonus hoferi, a parasitic fungus of the herring, Clupea harengus. II. The gross and microscopic lesions produced by the parasite., Ibid., vol. 17, no. 2, pp. 491-501, illus.

Ellis, Marjorie F.
1930a Ichthyophonus hoferi, a flounder parasite new to North American waters. Proc. and Trans. Nova Scotian Inst. Sci., vol. 17, pp. 185-192, illus.

1930b Protozoan fish parasites of the Saint Andrews region. Ibid., vol. 17, pp. 268-275, illus.

Fish, Ffederic F.
1934 A fungus disease in fishes of the Gulf of Maine. Parasitology, vol. 26, no. 1, 16 p., illus.

Graham, Michael
1936 Investigations of the herring of Passamaquoddy and adjacent regions. Jour. Biol. Bd. Can., vol. 2, no. 2, pp. 95-140, illus.

Huntsman, Archibald G.
1933 Heat and cold make herring seasons in Passamaquoddy. Progress Rept. Atl. Biol. Sta., no. 7, pp. 3-6, illus.

1934 Herring and water movements. In James Johnstone Memorial Volume, Univ. Press Liverpool, Liverpool, pp. 81-96, illus.

Jepps, M. W.
1937 On the protozoan parasites of Calanus finmarchicus in the Clyde Sea Area. Quart. Jour. Micr. Sci., vol. 79, pp. 589-658, illus.

Sproston, Nora G.
1944 Ichthyosporidium hoferi (Plehn and Mulsow, 1911), an internal parasite of the mackerel. Jour. Mar. Biol. Ass., vol. 26, no. 1, pp. 72 - 98, illus.

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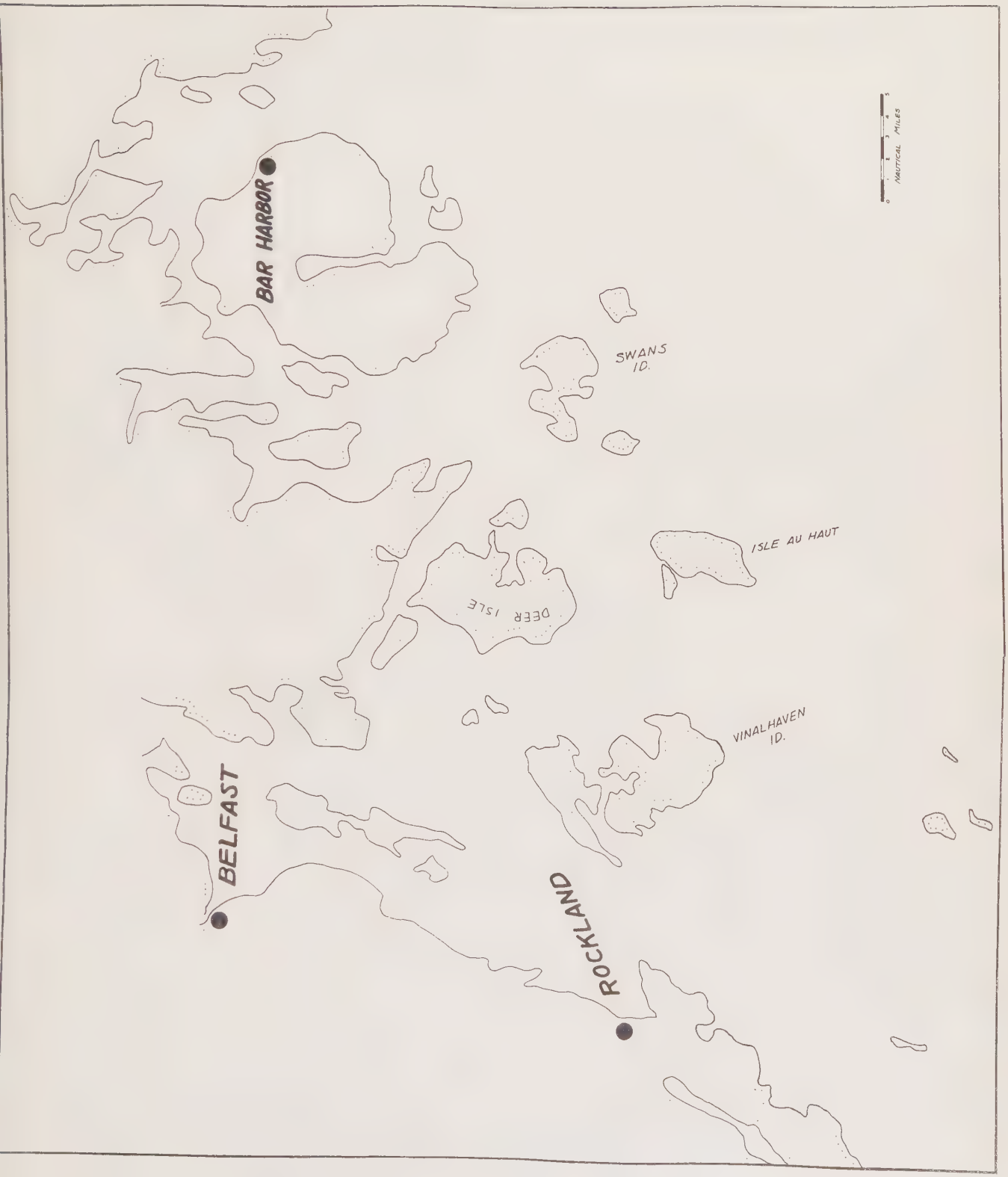


Figure 1. The Eastern Maine herring region.

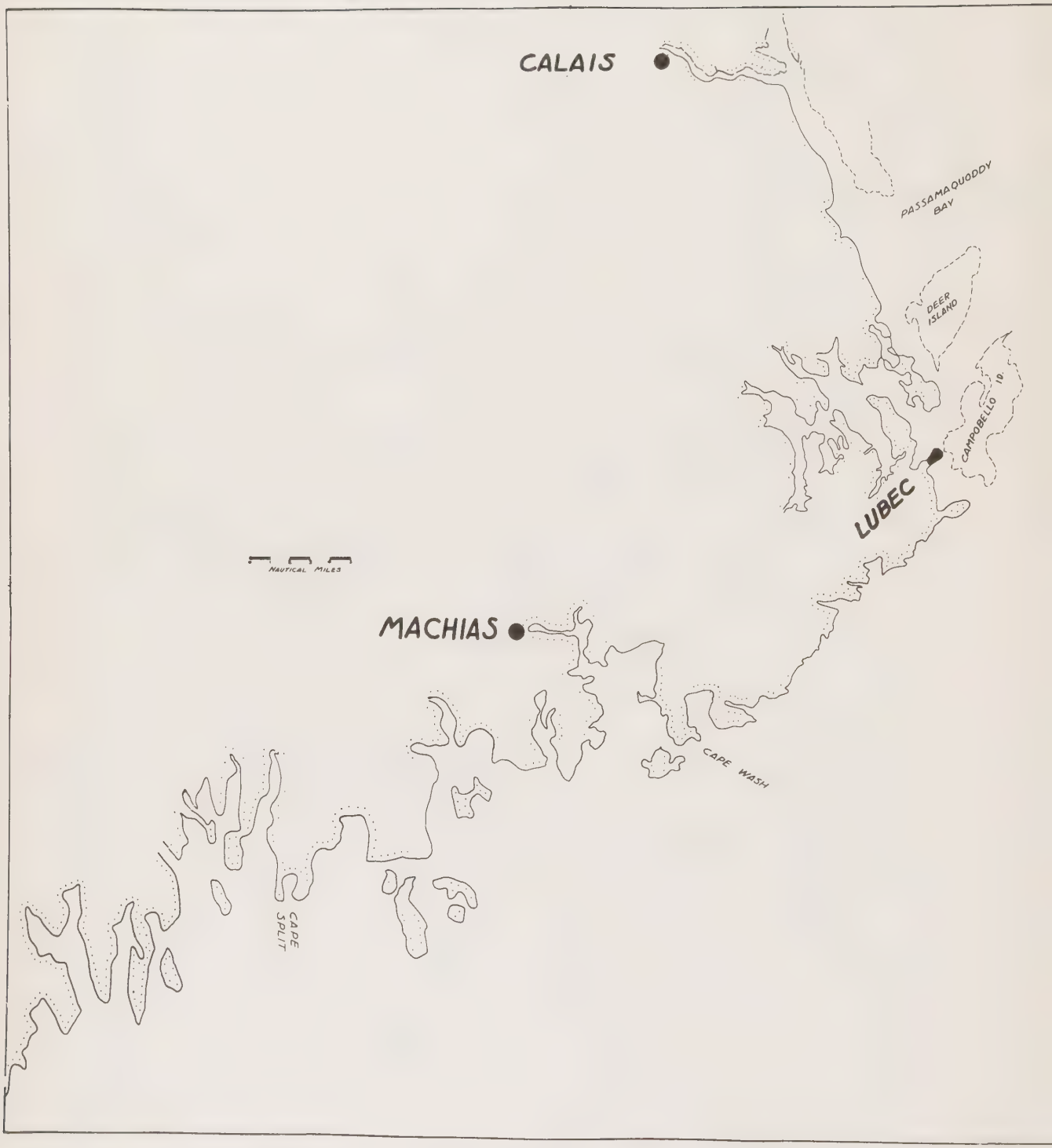


Figure 2. The Central Maine herring region.

Figure 3. The Western Maine herring region.

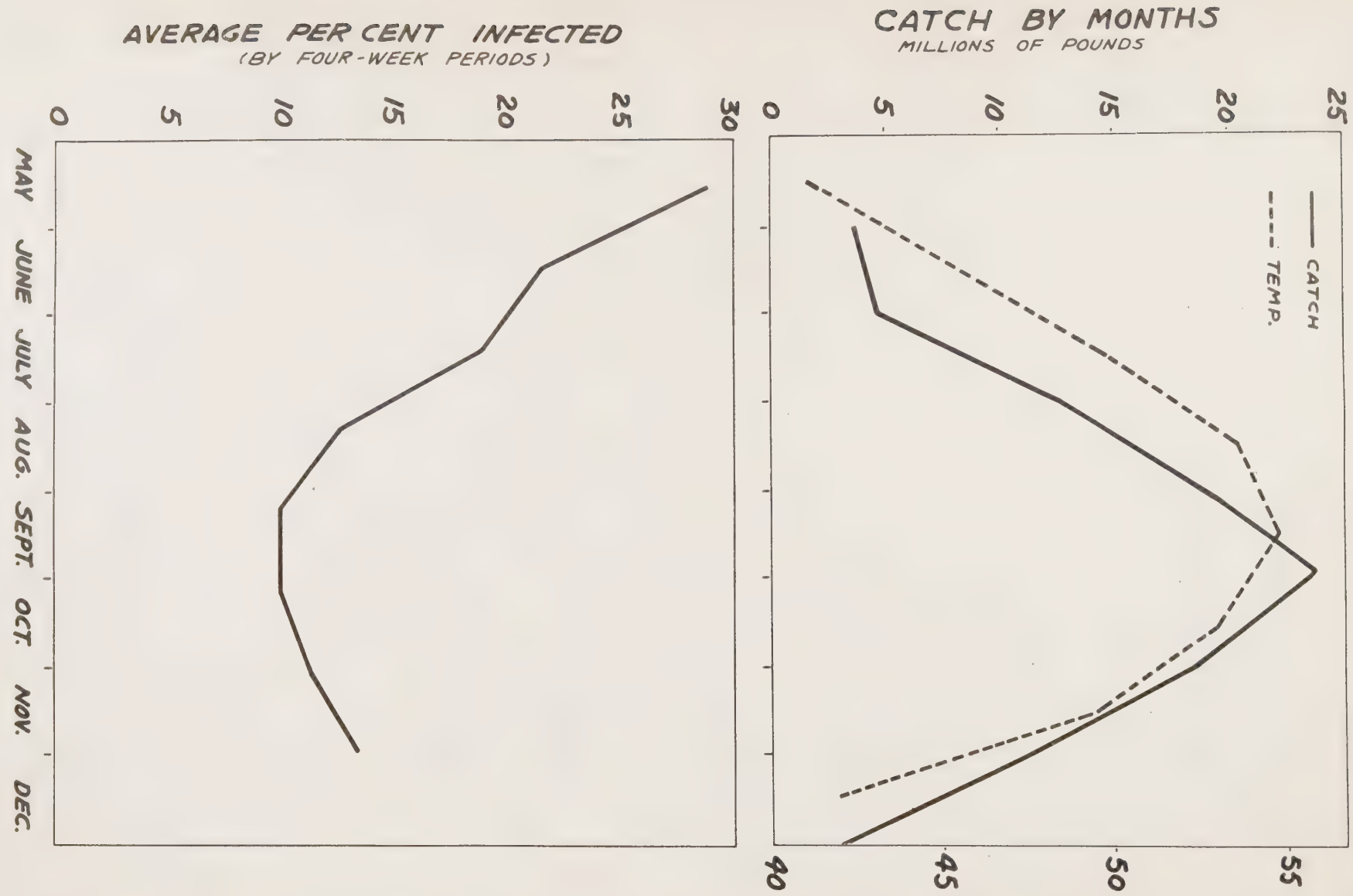


Figure 4. Relationships between the monthly New Brunswick herring catch, the average monthly surface water temperatures at Eastport, Maine and the average incidence of fungus infection in New Brunswick herring by four week intervals.

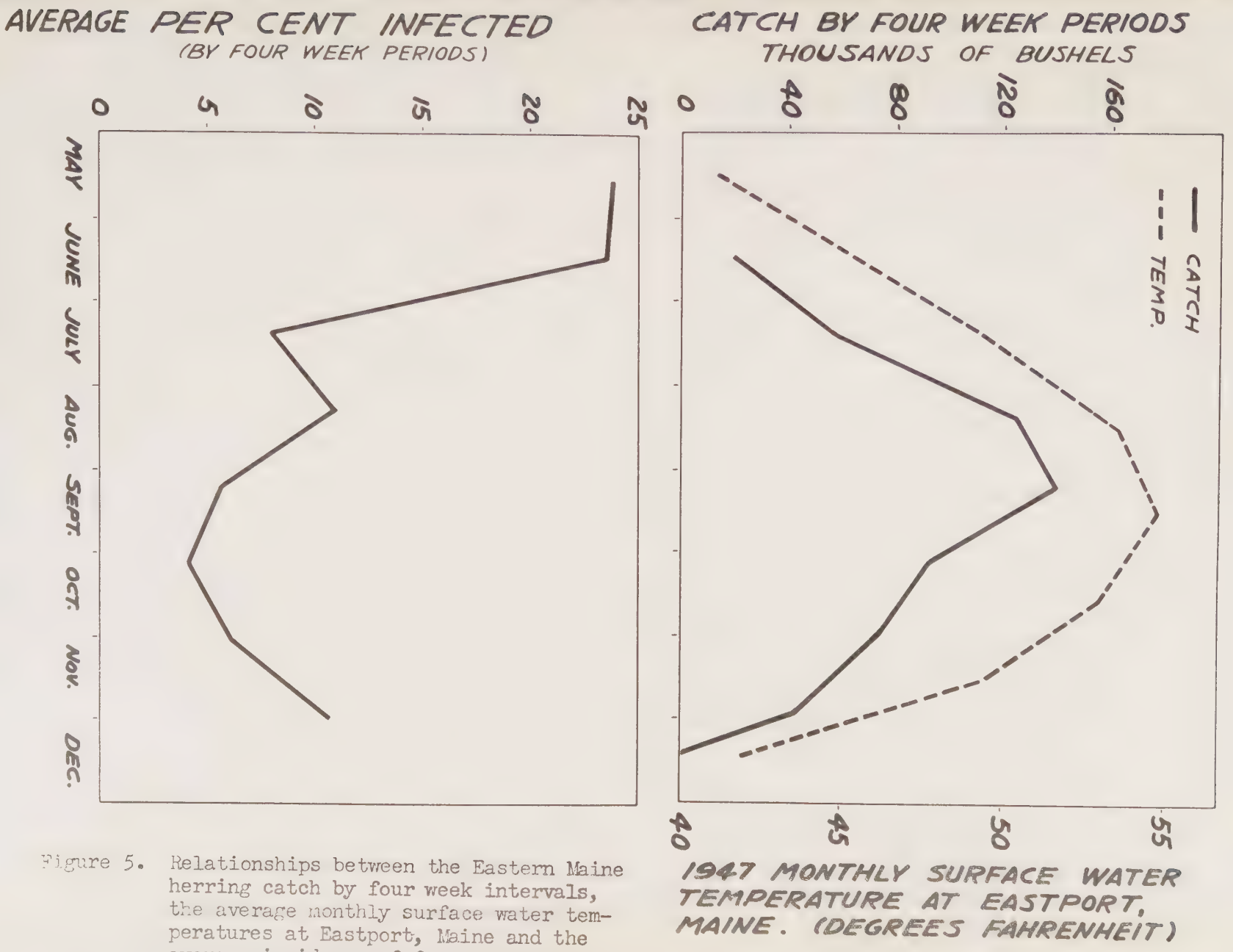


Figure 5. Relationships between the Eastern Maine herring catch by four week intervals, the average monthly surface water temperatures at Eastport, Maine and the average incidence of fungus infection in Eastern Maine herring by four week intervals.

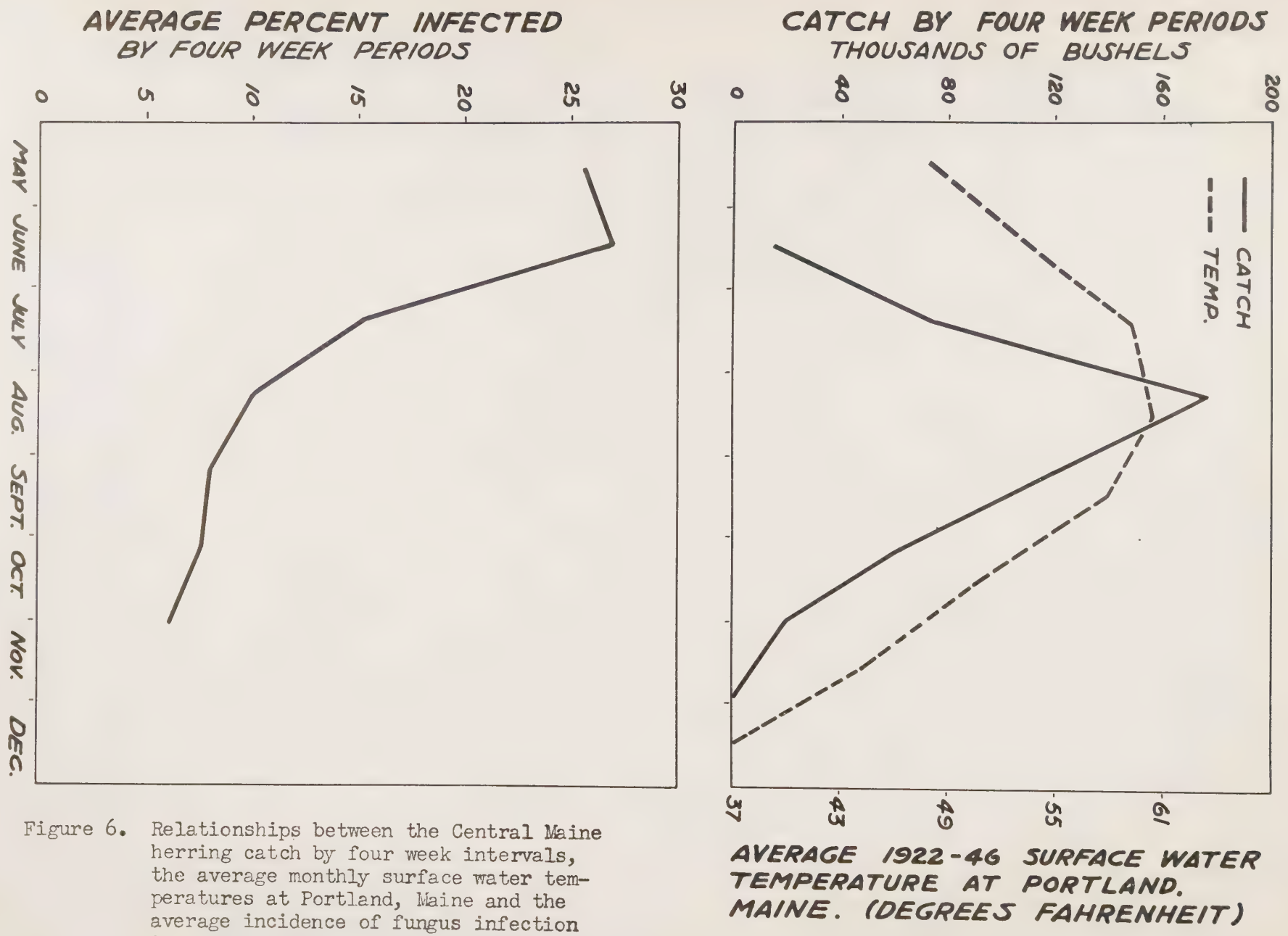
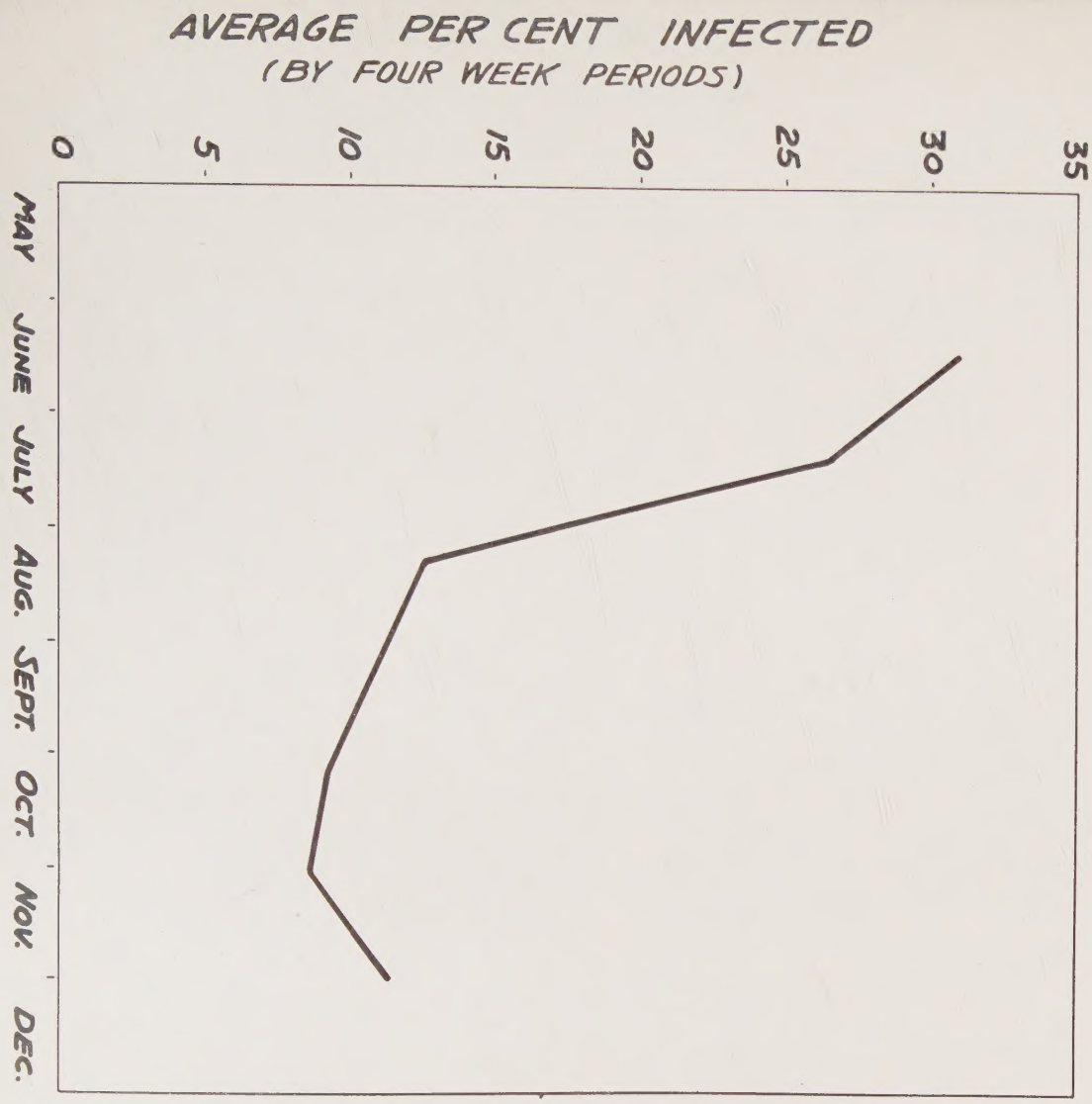


Figure 6. Relationships between the Central Maine herring catch by four week intervals, the average monthly surface water temperatures at Portland, Maine and the average incidence of fungus infection in Central Maine herring by four week intervals.



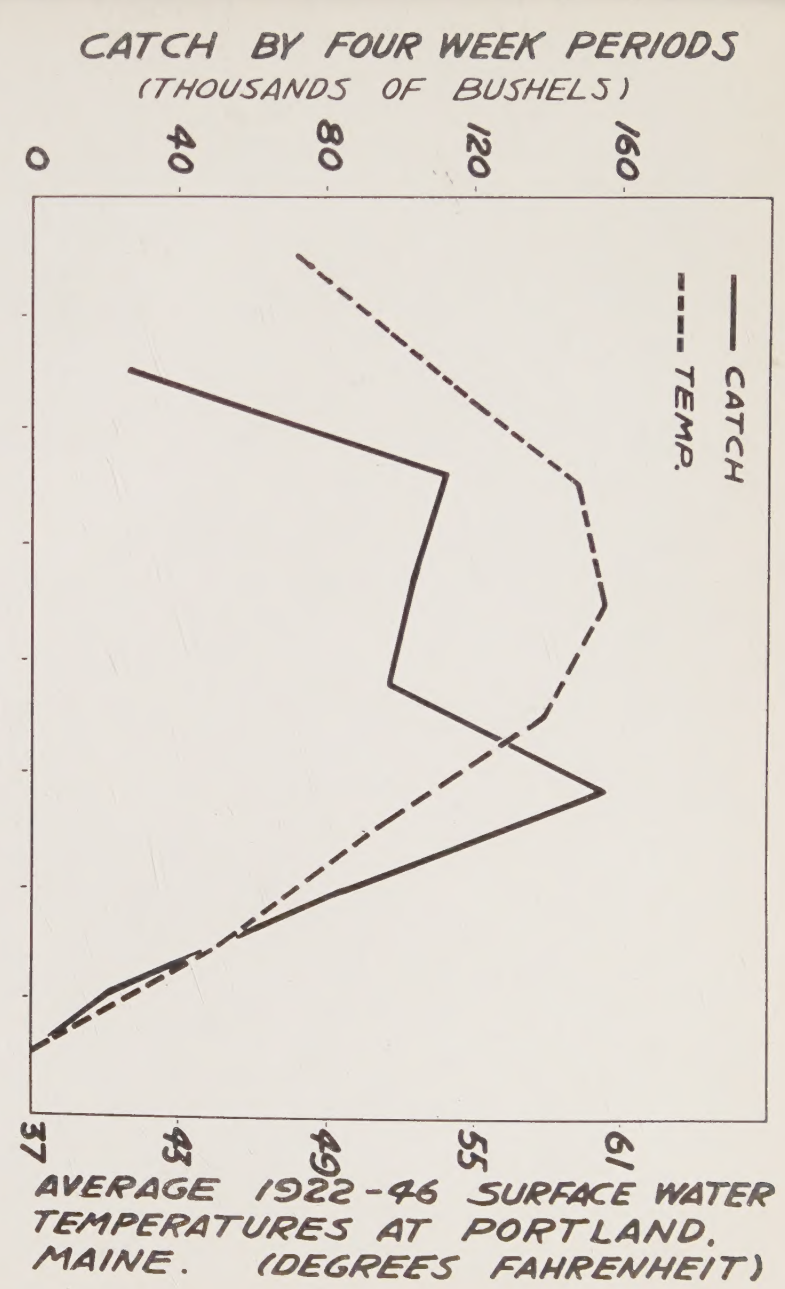


Figure 7. Relationships between the Western Maine herring catch by four week intervals, the average monthly surface water temperatures at Portland, Maine and the average incidence of fungus infection in Western Maine herring by four week intervals.